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Spectral analysis of meteorites ablated in a wind tunnel

A. Drouard (1), P. Vernazza (1), S. Loehle (2), J. Gattacceca (3), T. Zander (2), M. Eberhart (2), A. Meindl (2), R. Oefele (2), J. Vaubaillon (4) and F. Colas (4)

(1) Aix Marseille Univ, CNRS, LAM, Laboratoire d'Astrophysique de Marseille, Marseille, France (alexis.drouard@lam.fr)
(2) High Enthalpy Flow Diagnostics Group, Institut für Raumfahrtsysteme, Universität Stuttgart, Pfaffenwaldring 29, D–70569 Stuttgart, Germany (3) CNRS, IRD, CEREGE UM34, Aix Marseille Université, 13545, Aix en Provence, France (4) IMCCE, Observatoire de Paris, Paris, France

Abstract

Meteor spectroscopy is used to constrain the composition and thus nature of incoming meteoroids. Over the last decades, spectra have been recorded in the visible range (mostly between 360 and 700 nm), with typical spectrograph dispersions close to the namometer by pixel (e.g., 1.1 or 1.6 $nm.pix^{-1}$ for spectrographs in Czech Republic [2] or 2.5 $nm.pix^{-1}$ for those in Spain [5]). If the number of spectroscopic observations of meteors has globally increased, it remains low compared to the number of photometric records.

In complement to these observations, experiments in the laboratory have been undertaken to better understand meteor science. Specifically, various experiments were performed with the aim to study the process of meteorite ablation, but no experiment has so far recorded emission spectra of ablated meteorites, except [6] who recorded spectra of LASER irradiated meteorites. Recently and for the very first time, experiments simulating vaporization of a meteorite sample were performed in a wind tunnel near Stuttgart, Germany, with the specific aim to record emission spectra of the vaporized material [3]. Using a high enthalpy air plasma flow for modeling an equivalent air friction of an entry speed of about 10 $km.s^{-1}$, three meteorite types (H, CM and HED) and two meteoritical analogues (basalt and argillite) were ablated and high resolution spectra were recorded simultaneously.

The spectra were acquired with a spectrograph Aryelle 150. This instrument covers a large wavelength range (from 250 to 880 nm) with a high spectral resolution of 43 $pm.pix^{-1}$ at short wavelengths and 143 $pm.pix^{-1}$ at longer wavelengths [3]. We present a portion of the H chondrite spectrum in Fig. 1 and a list of the identified lines in Table 1.

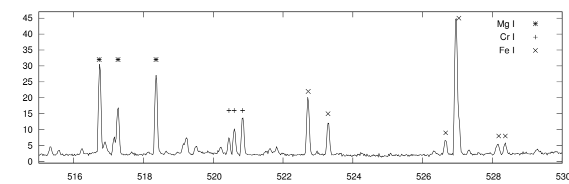

Figure 1: H chondrite spectrum over the 515-530 nm range.

Table 1: List of the identified lines over the 515-530 nm range.

λ (nm)	Element	A_{ul} (s^{-1})
516.73	Mg I	1.13×10^7
517.27	Mg I	3.37×10^7
518.36	Mg I	5.61×10^7
520.45	Cr I	5.09×10^7
520.60	Cr I	5.14×10^7
520.84	Cr I	5.06×10^7
522.72	Fe I	2.89×10^6
523.29	Fe I	1.94×10^7
526.66	Fe I	1.10×10^7
527.04	Fe I	3.67×10^6
528.18	Fe I	5.00×10^6
528.37	Fe I	1.02×10^7

After the identification of all atomic lines, we performed a detailed study of our spectra using two approaches: (i) by direct comparison of multiplet intensities between the samples and (ii) by computation of a synthetic spectrum to constrain some physical parameters (temperature, elemental abundance) following the work by [1]. Finally, we compared our results to the elemental composition of our samples and we determined how much compositional information can be retrieved for a given meteor using visible sectroscopy.

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